# Chevron
# EMC

## Well Abandonment Pilot Test PHA

### Conducted on
### 10/08/2013 and 11/18/2013
### Bishop Ranch 1, San Ramon, Ca. USA

**Issued by:**

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| A | 12/13/2013 | Draft for team review |
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| | | |

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# 1 Overview

## 1.1 Introduction

The Process Hazards Analysis (PHA) Study is a qualitative study which is a key component for implementation of Sub-Procedure 3 within the Chevron Corporate HES Risk Management Standard Process (also known as RiskMan2). The PHA Study is a systematic and comprehensive review of a process or change to:

- Identify and understand hazards associated with a process or change;
- Analyze the significance of the hazards;
- Assess the adequacy of the safeguards; and
- Develop recommendations to mitigate the hazards where justified.

A PHA study may use a number of possible methodologies such as a Hazard and Operability (HAZOP) review or a What If/Checklist review.

This PHA Study report documents the process and findings for abandonment of groundwater monitoring wells by explosives & blast perforating without the need for a drilling rig, the need to conduct air-knifing, reduce waste generated, and deliver a process that meets or exceeds our OE/HES goals, and lower costs. Systems studied were:

- Mobilization & Setup
- Assemble String
- Load Well
- Detonate Charge
- Backfill and Restore

For the study, a team was convened and guided through the What If structured process. Participants of the PHA Study and their experience are listed in Appendix B. The information used during the study is listed in Appendix C.

The Well Abandonment Pilot Test What If PHA was conducted at EMC on 10/08/2013 and 11/18/2013 and meets the requirements of the Chevron RiskMan2 Qualitative Risk Assessment Procedure.

This report contains the results from the PHA Study including:

- A qualitative Health, Safety, Environmental and Asset risk profile.
- A description of the identified risks which were prioritized using the Chevron Integrated Risk Prioritization Matrix.
- Recommendations generated for the identified risks including, as appropriate, further risk assessments.

## 1.2 Scope

The Well Abandonment Pilot Test What If PHA study scope included:

- Mobilization & Setup - Mobilize to site and communicate roles/responsibilities through tailgate, Establish work exclusion zones, Confirm/measure well TD and Receive & store explosive & blasting materials onsite.
- Assemble String - Lower tremie pipe into well and Assemble string at surface,
- Load Well - Weighting and lowering string into well, Fill well with seal material to surface, Manage well water displacement, Place containment cover over well, Clear area, Setup seismograph and Attach detonator.
- Detonate Charge - Detonate Charge
- Backfill and Restore - Remove well 'containment' cover, Refill with seal material to 5' below surface, Excavate and remove top five feet of well casing , Provide mushroom cap, Backfill, Restore site, Demobilize and Administrative close-out.

## 1.3 Objectives

The purpose of a PHA Study is to evaluate the potential risks to human health and safety, the environment and certain asset risks, based upon the information available. The PHA Study is used to:

- Logically and consistently evaluate risks;
- Obtain a preliminary understanding of these risks; and
- Determine areas where initial risk reduction should be considered.

All processes that require a qualitative risk assessment (PHA) as identified through the RiskMan2 Procedures should be periodically revalidated on an established frequency in accordance with applicable regulations and OpCo or BU procedures.

# 2 Methodology

## 2.1 What If / Checklist Study Procedure

The what-if technique is a systematic method for examining the response of a process system to equipment failures, operator errors and off-normal process conditions. The team uses the what-if analysis technique to brainstorm the various types of accidents and deviations from normal operation that can occur within the process. For example: What if the pump stops?

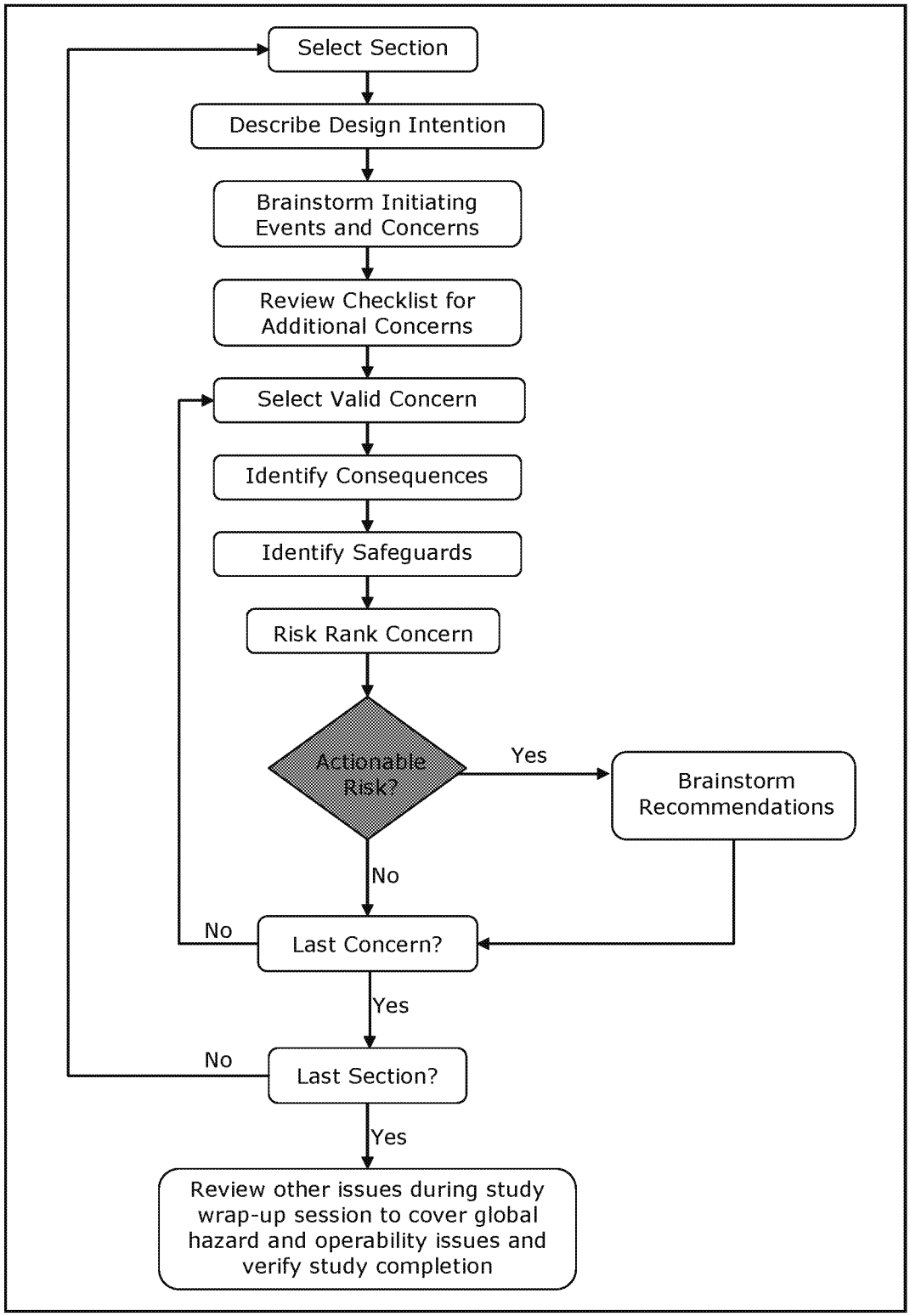
During brainstorming of what-if questions, the team focuses on initiating causes/events rather than consequences.

The specific steps of the What If / Checklist Study methodology used in the assessment are:

- Select section or node to be considered
- Describe the design intention of the section
- Brainstorm to identify concerns
- Review the standard checklists for additional potential concerns
- Select a valid concern
- Identify consequences
- Identify existing and verifiable safeguards
- Risk rank the concern
- Develop recommendations to address actionable risks or where necessary to ensure management of risk is consistent with the Chevron Way
- Continue the process until all concerns in a section have been evaluated and all sections of the workshop have been completed
- Review global concerns and other issues during the wrap up session and verify study is complete.

These are illustrated as a flow path in Figure 2.1.

**Figure 2.1: What If / Checklist Methodology Flowchart**



## 2.2 Integrated Risk Prioritization Matrix

The Integrated Risk Prioritization Matrix used in the PHA Study is included in Appendix E. In performing qualitative risk priority ranking, each cause-consequence scenario was evaluated based on the severity of potential consequences and how probable it is that these consequences might fully develop (likelihood) with safeguards in place.

The consequence ranking (1 to 6) and likelihood ranking (1 to 6) were combined using the Integrated Risk Prioritization Matrix to provide a risk priority ranking (1 to 10). Risk rankings are documented with "C" representing Consequence, "L" representing likelihood, and "R" representing risk priority levels. It is important to note that for those functional areas of concern that are not risk ranked, the lack of risk ranking implies that the particular risk category was not applicable for the scenario in question.

### 2.2.1 Risk Priority Rankings

The Integrated Risk Prioritization Matrix rankings are numbered and aligned with associated required actions for health, environment and safety risks, these include:

- **1, 2, 3, 4** – Short-term, interim risk reduction required. Long term risk reduction plan must be developed and implemented.
- **5** – Additional long term risk reduction required. If no further action can be practicably taken, Strategic Business Unit (SBU) management approval must be sought to continue the activity.
- **6** – Risk is tolerable if reasonable safeguards / managements systems are confirmed to be in place and consistent with relevant Risk Reduction Procedure and Closure Guidelines.
- **7, 8, 9, 10** – No further risk reduction required. Additional risk reduction will be implemented if required by the Chevron Way.

The PHA Study provides recommendations for all risk priority rankings 1 - 5, as well as events or conditions with low likelihood and high consequence that may require further risk evaluation. Further, recommendations were provided for risks where they would eliminate or mitigate the potential causes and / or consequences predicted for the scenario.

Appendix F contains the comprehensive study worksheets which summarizes the system descriptions and design intents, the deviations, potential causes, possible consequences, the safeguards / controls that are in fact, in place, the functional area of concern (**S** -Safety, **H** -Health, **E** - Environmental and **A** -Asset) for the scenarios evaluated, the risk priority ranking where applicable and the recommendations if any.

# 3 Compliance with Relevant Process Safety Requirements

This study is consistent with the PHA techniques of applicable process safety management standards throughout the world as follows:

## 3.1 Hazards of the Process

The What-If/Checklist techniques were used to identify and evaluate the hazards of the process. These techniques are recognized as acceptable methods of evaluating process hazards. Specifically, API (API RP-750 and API 14J) and the American Institute

of Chemical Engineers (Hazard Evaluation Procedures, 2nd Edition, Center for Chemical Process Safety of the American Institute of Chemical Engineers) recognize the value of these methodologies in analyzing process hazards. The team based its evaluation of the hazards on the nature of the process materials involved (e.g., flammability of hydrocarbons), the process conditions (level, pressure, etc.), and the team members' experience.

The major hazards introduced are:

1. personnel and public contact with explosives or projectiles
2. personnel and public vehicle/pedestrian interaction
3. personnel and public contact with electrical utilities

## 3.2 Identification of Previous Incidents with Potential for Catastrophic Consequences

Previous incidents, both on this facility and at similar facilities, were discussed during the course of the PHA. The experience of the team members was the basis for previous incident review.

A case of "snap flash detonation" where a moving vehicle caught the charge line which wrapped around the wheel and led to an unintended detonation. The team determined the following safeguards would reduce the likelihood of this incident: Trunkline spool is rolled up and blaster is guarding spool, all moving vehicles parked outside of exclusion zone and non-electrical trunkline. The team also made a recommendation to setup routing operations prior to installing string to reduce potential for accidental contact with the trunkline.

## 3.3 Engineering and Administrative Controls and the Consequences of Controls Failure

When determining the consequences of a given scenario, the team assumed that all existing protection systems would fail to work (e.g., operators are not trained, procedures are not followed, alarms and other safeguards are not tested and, as a result, may not provide adequate warning or protection). This technique allowed the team to evaluate the "worst case" consequences of a particular event.

The team evaluated each control or safeguard individually to determine if it is viable and can be claimed as a legitimate safeguard. The adequacy of procedures and training was reviewed. Maintenance and inspection practices were discussed, including alarm and shutdown testing programs. Only those safeguards that the team determined to be truly effective were claimed. The more severe the consequences, the more the team will focus on the need for specific, redundant, and reliable safeguards (both engineering and administrative controls). The team made a judgment as to whether or not additional controls or safeguards should be considered.

## 3.4 Qualitative Evaluation of the Possible Safety and Health Effects of Failure of Controls on Employees in the Workplace

Throughout the study, the team performed a qualitative evaluation of a failure of controls. The judgment of the team is reflected in the Risk-Ranking columns of the

various worksheets. To support management's objective of prioritizing issues arising from the PHA, the team used a risk-ranking matrix to aid in determining if a recommendation was justified based upon the developed consequences and identified safeguards. After the consequences and safeguards were developed, the scenario was evaluated based on how serious the potential consequences were, assuming no safeguards were in place (severity), and how probable it was that the scenario would fully develop to those consequences given the identified safeguards (likelihood). The consequence ranking (1 to 6) and likelihood ranking (1 to 6) were combined using the risk-ranking matrix to provide a qualitative risk ranking (1 to 10). Each developed cause/consequence scenario was ranked with an SLR ranking; "C" representing Consequence, "L" representing Likelihood, and "R" representing Risk. The risk-ranking matrix used during this study is presented in Appendix D.

## 3.5 Human Factors

While the PHA cannot be a substitute for a complete human error analysis, it can be a very effective tool for identifying those scenarios where human error can significantly contribute to the risk. Specifically, the PHA technique can identify where human error:

- Initiates an event of concern. Examples would be a block valve closed or opened in error, a controller setpoint entered incorrectly, or a procedure not followed.
- Results in failure to mitigate the consequence(s) of the event. An example of this would be when an operator, receiving confusing or conflicting signals about a process upset, is unable to determine the actual cause of the event and responds with inappropriate action. The PHA technique helps to identify such built-in traps in the system.
- Reduces the effectiveness of safeguards that would normally mitigate the risk associated with a cause/consequence scenario. Examples include procedural errors by operators; lack of, or poorly managed, safeguard testing programs; and design errors that impede operator response, such as poorly located or poorly labeled emergency shutdown equipment.

Design or procedural features that impact human performance, such as equipment accessibility, labeling, clarity of procedures, simultaneous activities, and operator fatigue, were also weighed into the final evaluation of risk for those events of concern to which they apply. Specific discussions on human factor considerations are documented throughout the checklists and worksheets.

## 3.6 Facility Siting

The PHA is not a substitute for a complete facility siting assessment however it can address facility siting concerns through consideration during scenario development of how the location and layout of equipment contributes to the risk. The following are considered:

- Arrangement of equipment within the process.
- Location of the process equipment with respect to population centers on site (e.g., control rooms, offices, maintenance shops, warehouses and lunch rooms), offsite neighbors, and environmental receptors.

- Location of the potential release points relative to likely ignition sources (for flammables).
- Location of the process equipment with respect to other processes and/or off-site receptors that can be affected by releases from the process being analyzed, or where releases from neighboring units can affect the process being analyzed.

The PHA team considers these factors through a combination of the following activities:

- Including at least one employee who is familiar with the layout of the process equipment on the PHA team.
- Referring to facility aerial photos and maps when discussing specific release scenarios.

Specific discussions on facility siting considerations are documented throughout the checklists and worksheets.

# 4 Results

## 4.1 Risk Summary

Table 4.1 present the number of the risks by risk priority ranking and Tables 4.2 presents the risk rankings evaluated across the systems and nodes.

**Table 4.1: Summary of Identified Risks per Risk Priority Ranking**

| Risk Priority Ranking Level | Number of Risks Identified |
|---|---|
| (Risk Levels 1,2,3,4) Short-term, interim risk reduction required. Long term risk reduction plan must be developed and implemented | 0 |
| (Risk Level 5) Additional long term risk reduction required. If no further action can be practicably taken, Strategic Business Unit (SBU) management approval must be sought to continue the activity | 0 |
| (Risk Level 6) Risk is tolerable if reasonable safeguards / managements systems are confirmed to be in place and consistent with relevant Risk Reduction Procedure and Closure Guidelines | 4 |
| (Risk Levels 7, 8, 9,10) No further risk reduction necessary | 39 |

## Table 4.2: Risk Priorities across Systems and Nodes

| Node | Recommendations | Number of risks requiring recommendations | Number of Study Items | | | |
|---|---|---|---|---|---|---|
| | | | 1 - 4 | 5 | 6 | 7 - 10 |
| 1. Mobilization & Setup | 1, 2, 3 & 4 | 12 | 0 | 0 | 0 | 13 |
| 2. Assemble String | 1, 5, 6, 7, 8 & 9 | 6 | 0 | 0 | 3 | 5 |
| 3. Load Well | 1, 5, 10, 11, 12, 13, 14 & 15 | 8 | 0 | 0 | 1 | 8 |
| 4. Detonate Charge | 16 | 3 | 0 | 0 | 0 | 8 |
| 5. Backfill and Restore | 17 | 1 | 0 | 0 | 0 | 5 |
| ***TOTAL*** | | ***30*** | ***0*** | ***0*** | ***4*** | ***39*** |

## 4.2 Recommendations

Recommendations were captured for the hazards that were evaluated into Risk Levels 1 - 5 requiring action or any actionable risk. Additionally, recommendations were postulated as necessary to ensure that the management of risks is consistent with the Chevron Way, regardless of the estimated risk.

The PHA team made a total of 17 recommendations aimed at reducing safety health and environmental risk, or promoting reliable operation of the facility. Along with appearing in the worksheets, suggested actions identified by the study team are documented in the "Recommendations List". This list can be found in Appendix A of this report.

### 4.2.1 Potentially Significant Findings

There were no potentially significant findings that will have a large impact to the safety, operability or reliability of the facility.

### 4.2.2 General Finding

As the use of explosives is a novel well destruction technique there are several issues for which it is recommended to enter into early negotiation with the Regulator to gain approval for the technique and other associated approvals e.g. use of cement grout retardant and flow improver additives, the reuse of displaced water to make cement grout and grout placement techniques to reduce displaced water from the well.

# Appendix A: Well Abandonment Pilot Test Recommendations List

| Recommendations | Max Risk | Reference Number | CC |
|---|---|---|---|
| 1. The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business interruption, particularly during Assemble String, Load Well and Detonate Charge phases. | 6 | 1.1.2.1.1 | A |
| | | 1.1.2.2.1 | A |
| | | 1.1.4.1.1 | A |
| | | 1.1.4.2.1 | S |
| | | 2.1.1.1.2 | S |
| | | 3.1.5.2.1 | S |
| 5. The concern is members of public entering the blast exclusion zone which is marked by caution tape. The team discussed the potential for members of the public, particularly children, to by-pass caution tape which marks the exclusion zone. Recommend to consider alternative methods to reduce potential for personnel and public entry into the exclusion zone (e.g. hard barricades). | 6 | 2.1.1.1.1 | S |
| | | 3.1.5.2.2 | S |
| 8. The concern is possibility of blast string or trunkline damage leading to premature firing, misfire and requirement to run another string. The team discussed the string damage could occur due to accidental contact with the trunkline by equipment and vehicles. Recommend to setup routing operations prior to installing string to reduce potential for accidental contact with the trunkline. | 6 | 2.1.5.1.1 | S |
| 9. The concern is explosives may be delivered to non-authorized personnel at the well abandonment work site. The team discussed the potential for illegal or terrorist use of the explosives if the delivery company does not check the qualifications of the person taking receipt of the explosives onsite. Recommend to consider making a request to the licensed explosives delivery company to review how their procedures ensure explosives are only provided to authorized personnel. | 6 | 2.1.8.1.1 | S |
| 2. The concern is possible vehicle/pedestrian interaction whilst maneuvering well destruction vehicles and equipment in a constrained work area. The team noted sites may have multiple buildings, equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment. Recommend to consider performing field walk through of designated route particularly when backing vehicles. | 7 | 1.1.2.3.1 | S |
| 13. The concern is potential for personnel to be injured by cement pump discharge hose whip due to overpressure failure. Recommend to consider the use of whip checks on cement pump discharge hoses. | 7 | 3.1.3.1.1 | S |
| 16. Concern is future wells to be abandoned may be adjacent to existing assets and utilities which may be damaged due to excess vibration from the explosive shock wave. The team discussed the need to estimate damage to assets and utilities by conducting detailed blast modeling to determine safe distances and charge density however, there is currently insufficient propagation velocity data for typical soil types. Recommend to conduct multiple seismic monitoring at test well sites in typical soil types to gather velocity data to support future detailed blast modeling of future wells which are adjacent to existing assets and utilities. | 9 | 4.1.5.1.1 | A |
| 17. Concern is the potential for excessive displacement of displaced water from the well at the surface due to the regulatory requirement to place cement grout from well total depth to the surface. The team discussed the potential for displaced water from the well to be reduced by placing the cement grout from above the water level to displace water back to the formation rather than displacement to surface. Recommend to consider negotiation with the Regulator to allow placement of cement grout without tremie pipe or tremie pipe placement above well total depth to place the cement grout above the water level and displace water back to the formation. | 9 | 5.1.3.1.1 | E |
| 3. Concern is delay to project schedule with associated "standby" costs and remobilization and loss to materials should core personnel be unavailable (e.g. sickness). The team discussed the criticality of each skill set that are essential to completing the well abandonment operation in particular the need for a competent Blaster. Recommend to consider implementing a requirement for personnel to provide a 24-hr notification of not being fit for duty. | 10 | 1.1.6.1.1 | A |
| 6. The concern is possibility of blast string or trunkline damage leading to misfire and requirement to run another string or displace the grout from the wellbore and start again. The team discussed the damage could occur due to persons inadvertently pulling the blast string or trunkline against snag hazards and casing sharp edges. Recommend to consider minimizing sharp edges, adding protective tape to required sharp edges and enforcing good housekeeping activities where the string may come into contact with casing, well containment device and other touch points. | 10 | 2.1.2.1.1 | A |

| Recommendations | Max Risk | Reference Number | CC |
|---|---|---|---|
| 7. The concern is delay of project schedule if the total depth of the well cannot be achieved. The team discussed potential for root growth into wellbore or hole collapse to prevent the installation of the blast string to total depth. Recommend to consider pre-mobilization survey (schedule with USA marking surveys) and remediation to achieve actual measured well total depth (TD) prior to mobilization of the well destruction team. | 16 | 2.1.4.1.1 | A |
| 10. The concern is on-site quality control of cement grout slurry mix may not meet regulatory requirements for cement grout composition. The team discussed the variability of quality achieved if visual or volumetric measures were used. Recommend to utilize mud scales to measure cement grout composition to meet regulatory requirements for cement grout composition. | 16 | 3.1.1.1.1 | A |
| 11. The concern is the potential for cement grout viscosity to exceed the pumping ability through tremie pipe. The team discussed this may prevent the cement trash pump from keeping prime. Recommend to consider adding viscosity and flow improvers to cement grout to improve pumping characteristics. | 16 | 3.1.2.1.1 | A |
| 12. Concern is the requirement for regulatory approval of cement grout additives to achieve desired properties for operational and contingency measures. The team discussed the need to add viscosity and flow improvers to cement grout to improve pumping characteristics, retarder to allow placement of a propagation charge should the initial charge misfire or hangfire. Recommend to enter into early negotiation with the Regulator to gain approval for cement grout additives. | 16 | 3.1.2.1.2 | A |
| | | 4.1.3.1.2 | A |
| 14. Concern is regulatory standards may require displaced water from the well to be treated as waste requiring offsite disposal. The team discussed the potential for displaced water from the well to be reused to create cement grout for the next well to be abandoned. Recommend to negotiate with Regulator to gain approval for reuse of displaced water to make cement grout. | 16 | 3.1.4.1.1 | E |
| 15. Concern is reentry to the well to allow contingency measures should the detonation cord/charge move from planned placement in wellbore or a misfire or hangfire of the charge. The team discussed the potential for the cement to set during the time required to circulate out cement grout to recover well total depth or to rig up and deploy a propagation charge to well total depth. Recommend to consider a retardant additive to cement grout to allow contingency measures (e.g. circulate out cement grout to recover well total depth, deploy charge downhole). | 16 | 3.1.6.1.1 | A |
| | | 4.1.3.1.1 | A |
| 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard Analysis technique onsite with the whole work force to identify hazards, implement risk reduction safeguards and rehearse mitigation procedures prior to each step of the job. | Not ranked in workshop | 1.1.9.1.1 | S |
| | | 1.1.10.1.1 | S |
| | | 1.1.11.1.1 | H |
| | | 1.1.12.1.1 | S |
| | | 1.1.13.1.1 | S |
| | | 1.1.14.1.1 | H |

# Appendix B: Study Team and Credentials

## Table B1: Well Abandonment Pilot Test What If PHA Study Team

| First Name | Last Name | Company | Expertise | E-Mail Address |
|---|---|---|---|---|
| Alex | Amort | Cascade Drilling | Drilling | aamort@cascadedrilling.com |
| Brett | Arenas | Cascade Drilling | Drilling & HES | barenas@cascadedrilling.com |
| Brian | Waite | Chevron EMC | Project Management | BWaite@chevron.com |
| Craig | Gardner | Chevron ETC D&C | Cementing | Craig.Gardner@chevron.com |
| Jean | Wong | Chevron EMC | Scribe | JeanWong@chevron.com |
| Justin | Sobieraj | Arcadis | Project Management | Justin.Sobieraj@arcadis-us.com |
| Natalie | Woodard | Chevron EMC | Scribe | NWoodard@chevron.com |
| Tim | McGrath | Chevron ETC STU | PHA Facilitator | tim.mcgrath@chevron.com |
| Tylor | McMillan | Welenco | Blasting | mcmillans521@yahoo.com |

# Appendix C: Study Documentation

The Process Safety Information Checklist for the study and details of the drawings used in the Nodes are following.

## Table C1: Systems Documentation

| Drawing | Comment | Rev No | Revision Date | Place(s) Used |
|---|---|---|---|---|
| Advanced GeoEnvironmental, Inc - 13 November 2006, AGE-NC Project No. 02-0913, Page 2 of 5 (MW-1) | | | | |
| Advanced GeoEnvironmental, Inc. As-built Monitoring Well Construction Drawing: Figure 3 (MW-1) Project No. AGE-NC-02-0913 | | | 11/20/2006 | |
| Arcadis Cross Section A-A' Plan View, Figure 3 | | | | |
| Arcadis Hydrogeological Cross Section A-A', Figure 4 | | | | |
| Arcadis No Further Action Required Report - Site ID 309075 (pages 6, 7) | | | | |
| Arcadis Well/Boring Log Plot: MW-4; Project # B0046012.001 | | | | |
| Blast Perforation Methods for Water Well Abandonment | | | | |
| Blasters Rules | | | | |
| Blasting Safety Plan: Water Well Technology Inc / Welenco Blasting Operations Safety Plan | | | | |
| Blasting Work Plan Chevron MW-4 | Casing 2 inch to 75ft | Pending | 08/09/2013 | Nodes: 2 |
| CA Department of Water Resources: Bulletin 74-90: CA Well Standards; supplement to DWR Bulletin 74-81 | | | | |
| CA Department of Water Resources (DWR): Bulletin 74-81: CA Water Well Standards; minimum requirements for construction, alteration, maintenance, and destruction of water wells, monitoring wells, and cathodic protection wells in California | | | 06/30/1991 | |
| CA Groundwater Association; CGA Standard Practice Series – Article 299 (Destruction of Water Wells) | | | | |
| Cascade drilling Job Safety Analysis – Concrete Mixing in Wheel Barrow | | | | |
| Cascade drilling Job Safety Analysis – Concrete Mixing in with Mixing Machine | | | | |
| Cascade drilling Job Safety Analysis – Jackhammer Use | | | | |
| Department of the Treasure, Bureau of Alcohol, Tobacco and Firearms: License/Permit (18.US.C. Chapter 40, Explosives); License Permit # 9-CA-029-33-4D-01295 | | | | |
| DYNO Nobel (manufacturer) NONEL Lead Line (Shock Tube) Technical Information – MSDS #1124 | | | | |
| DYNO Nobel (manufacturer) NONEL MS 1.4B (Millisecond Delay Detonator) Technical Information – MSDS #1122 | | | | |
| DYNO Nobel (manufacturer) PRIMACORD (Detonating Cord) Technical | | | | |

| Drawing | Comment | Rev No | Revision Date | Place(s) Used |
|---|---|---|---|---|
| Information – MSDS #1126 | | | | |
| DYNO Nobel (manufacturer) Trojan SPARTAN (Cast Booster) Technical Information – MSDS #1108 | | | | |
| Instantel Blastmate III specifications sheet | | 7 | | |
| Job Safety Analysis Southern Pacific Monitoring Well MW-16B Destruction | Destruction of a well by blast perforating | | 04/29/2013 | Nodes: 1 |
| Material Safety Data Sheet (MSDS # 1122) for NONEL (Non-electric) Delay Detonartors | | | 06/13/2012 | |
| MSDS #1108 for Cast Boosters (not planned for Chevron MBU Work) | | | 06/28/2011 | |
| MSDS # 1126 for Detonating Cord | | | 09/06/2010 | |
| OSHA's Form 300: Log of Work-Related Injuries and Illnesses (Year 2012) | | | | |
| San Joaquin County Ordinance Code Section 9-1115.6, San Joaquin County Well Standards | | | | |
| State of CA Department of Justice, Certificate of Eligibility # 13584 | | | | |
| State of CA Division of Occupational Safety And Health, Blaster Certification/License ; Classification (E) Limited: Well Service Blasting (Limitation) Nonelectric initiation only | | | | Nodes: 3 |
| UPRR Job Safety Analysis - Well destruction by blasting perforating casing | | | | |
| Water Well Technology, Inc. / Welenco – "To Whom It May Concern" Neighborhood notification letter | | | | |
| Welenco Job Safety Analysis-rev1 – Well Abandonment | | | 10/04/2013 | |
| Welenco Operational Procedures: Misfires, Partial Detonation, Premature Firing | | | | |
| WWTI (Water Well Technology, Inc.) Welenco Job Safety Analysis (Arcadis) | | | | |
| WWTI / Welenco Blasting Work Plan (MW-1) | | | | |
| WWTI / Welenco Blasting Work Plan (MW-2) | | | | |
| WWTI / Wlenco Methods of Explosive Handling Onsite | | | | |

# Appendix D: Facilities / Activities Evaluated (Systems)

The systems evaluated during the PHA are outlined in Table D1 below.

## Table D1: Well Abandonment Pilot Test What If PHA Nodes Systems

| Node Title | Description | Design Intent |
|---|---|---|
| 1. Mobilization & Setup | Mobilize to site and communicate roles/responsibilities through tailgate<br>Establish work exclusion zones<br>Confirm/measure well TD<br>Receive & store explosive & blasting materials onsite | Authorized personnel handling and using materials<br>Actual TD must match well construction Logs<br>Exclusion zones = 50 feet |
| 2. Assemble String | Lower tremie pipe into well<br>Assemble string at surface | Only detonation string being utilized (no boosters)<br>Tremie pipe threaded (not coupled) |
| 3. Load Well | Weighting and lowering string into well<br>Fill well with seal material to surface<br>Manage well water displacement<br>Place containment cover over well<br>Clear area<br>Setup seismograph<br>Attach detonator | Weight and drop method of lowering string into well<br>Composition of sealant material to meet requirements of CWC 74.90<br>Placement of sealant material to meet requirements of CWC 74.90 |
| 4. Detonate Charge | Detonate Charge | Remain below peak velocity of 3"/sec and charge of size no greater than 50 grains/ft for PVC wells<br>Seismograph sample rate from 1,024 to 16,384 S/s per channel up to 65,536 S/s available on a single channel |
| 5. Backfill and Restore | Remove well 'containment' cover<br>Refill with seal material to 5' below surface<br>Excavate and remove top five feet of well casing<br>Provide mushroom cap<br>Backfill<br>Restore site<br>Demobilize<br>Administrative close-out | Well destruction to meet requirements of CWC 74.90 |

# Appendix E: Chevron Integrated Risk Prioritization Matrix

## Chevron Integrated Risk Prioritization Matrix

For the Assessment of HES & Asset Risks from Event or Activity

**Likelihood Descriptions & Index** (with confirmed safeguards)

| Likelihood Descriptions | Likelihood Indices | | Legend | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | *Legend applies to identified HES risks (see guidance documents for additional explanations)* | | | | | |
| | | | 1, 2 , 3, 4 - Short-term, interim risk reduction required. Long term risk reduction plan must be developed and implemented. | | | | | |
| | | | 5 - Additional long term risk reduction required. If no further action can be reasonably taken, SBU management approval must be sought to continue the activity. | | | | | |
| | | | 6 - Risk is tolerable if reasonable safeguards / management systems are confirmed to be in place and consistent with relevant requirements of the Risk Mitigation Closure Guidelines. | | | | | |
| | | | 7, 8, 9, 10 - Manage risk. No further risk reduction required. Risk reduction at management / team discretion. | | | | | |
| Consequences can reasonably be expected to occur in life of facility | 1 | Likely | 6 | 5 | 4 | 3 | 2 | 1 |
| Conditions may allow the consequences to occur at the facility during its lifetime, or the event has occurred within the Business Unit | 2 | Occasional | 7 | 6 | 5 | 4 | 3 | 2 |
| Exceptional conditions may allow consequences to occur within the facility lifetime, or has occurred within the OPCO | 3 | Seldom | 8 | 7 | 6 | 5 | 4 | 3 |
| Reasonable to expect that the consequences will not occur at this facility. Has occurred several times in the industry, but not in the OPCO | 4 | Unlikely | 9 | 8 | 7 | 6 | 5 | 4 |
| Has occurred once or twice within industry | 5 | Remote | 10 | 9 | 8 | 7 | 6 | 5 |
| Rare or unheard of | 6 | Rare | 10 | 10 | 9 | 8 | 7 | 6 |

Decreasing Likelihood

**Consequence Descriptions & Index** (without safeguards)

| Consequence Indices | | | Decreasing Consequence/Impact | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 6 | 5 | 4 | 3 | 2 | 1 |
| | | | Incidental | Minor | Moderate | Major | Severe | Catastrophic |
| Consequence Descriptions | Safety | | **Workforce**: Minor injury such as a first-aid. AND **Public**: No impact. | **Workforce**: One or more injuries, not severe. OR **Public**: One or more minor injuries such as a first-aid. | **Workforce**: One or more severe injuries including permanently disabling injuries. OR **Public**: One or more injuries, not severe. | **Workforce**: (1-4) Fatalities. OR **Public**: One or more severe injuries including permanently disabling injuries. | **Workforce**: Multiple fatalities (5-50). OR **Public**: multiple fatalities (1-10). | **Workforce**: Multiple fatalities (>50). OR **Public**: multiple fatalities (>10). |
| | Health (Adverse effects resulting from chronic chemical or physical exposures or exposure to biological agents) | | **Workforce**: Minor illness or effect with limited or no impacts on ability to function and treatment is very limited or not necessary. AND **Public**: No impact. | **Workforce**: Mild to moderate illness or effect with some treatment and/or functional impairment but is medically manageable. OR **Public**: Illness or adverse effect with limited or no impacts on ability to function and medical treatment is limited or not necessary. | **Workforce**: Serious illness or severe adverse health effect requiring a high level of medical treatment or management. OR **Public**: Illness or adverse effects with mild to moderate functional impairment requiring medical treatment. | **Workforce** (1-4): Serious illness or chronic exposure resulting in fatality or significant life shortening effects. OR **Public**: Serious illness or severe adverse health effect requiring a high level of medical treatment or management. | **Workforce** (5-50): Serious illness or chronic exposure resulting in fatality or significant life shortening effects. OR **Public** (1-10): Serious illness or chronic exposure resulting in fatality or significant life shortening effects. | **Workforce** (>50): Serious illness or chronic exposure resulting in fatality or significant life shortening effects. OR **Public** (>10): Serious illness or chronic exposure resulting in fatality or significant life shortening effects. |
| | Environment | | Impacts such as localized or short term effects on habitat, species or environmental media. | Impacts such as localized, long term degradation of sensitive habitat or widespread, short-term impacts to habitat, species or environmental media. | Impacts such as localized but irreversible habitat loss or widespread, long-term effects on habitat, species or environmental media. | Impacts such as significant, widespread and persistent changes in habitat, species or environmental media (e.g. widespread habitat degradation). | Impacts such as persistent reduction in ecosystem function on a landscape scale or significant disruption of a sensitive species. | Loss of a significant portion of a valued species or loss of effective ecosystem function on a landscape scale. |

**The above legend applies only to HES risks, where risk levels 1-6 are actionable and mandatory.**
**For risks that may result in facility damage, business interruption, loss of product, the "Assets" category below should be used.**
**Asset risk reduction is at the discretion of management. Under no circumstances may a direct or indirect translation of Asset loss to HES consequences, or between any discrete categories of HES consequences be inferred.**

**Consequence Descriptions & Index** (without safeguards)

| Consequence Indices | | | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| | | | Incidental | Minor | Moderate | Major | Severe | Catastrophic |
| Consequence Descriptions | Assets (Facility Damage, Business Interruption, Loss of Product) | | Minimal damage. Negligible down time or asset loss. Costs < $100,000. | Some asset loss, damage and/or downtime. Costs $100,000 to $1 Million. | Serious asset loss, damage to facility and/or downtime. Costs of $1-10Million. | Major asset loss, damage to facility and/or downtime. Cost >$10 Million but <$100 Million. | Severe asset loss or damage to facility. Significant downtime, with appreciable economic impact. Cost >$100MM but <$1billion. | Total destruction or damage. Potential for permanent loss of production. Costs >$1billion. |

**This matrix is endorsed for use across the Company.**
**It is not a substitute for, and does not override any relevant legal obligations.**
**Under no circumstances should any part of this matrix be changed or modified, adapted or customized.**
**This matrix identifies health, safety, environmental and asset risks and is to be used only by qualified and competent personnel.**
**Where applicable it is to be used within the Riskman2 structure and governance of an OE Risk Management Process. If applied outside of these Processes, it is also mandatory to manage identified intolerable risks and comply with the Risk Mitigation Closure Guidelines.**

# Appendix F: Well Abandonment Pilot Test What If PHA Worksheets

**Node Title:** 1. Mobilization & Setup

**Drawing:** Job Safety Analysis Southern Pacific Monitoring Well MW-16B Destruction

**Design Intent:** Authorized personnel handling and using materials

Actual TD must match well construction Logs

Exclusion zones = 50 feet

| What If? | Consequences | CC | Safeguards | Risk Priority C | L | Risk | Recommendations | Comment 1 |
|---|---|---|---|---|---|---|---|---|
| 1. Permits (Fire Marshall, Sheriff Coroner's office, Environmental Health Dept., Dept of Justice, OSHA, ATF, etc.) are not in place | 1. Impact to Asset: Delay to project schedule (Fire Marshal not be available for onsite inspection on day of activity; Fire Marshall permit is date specific) | A | Pre-shift inspection checklists and inspections (DOT ready, review materials,equipment, toolbox review)<br>Lead time required for permits is known (4 weeks maximum lead time)<br>Permit will not need to be reissued if date of job changes; distributor will be notified and explosives will not be delivered<br>Chevron environmental well destruction permit has a large window for job date change | 6 | 5 | 10 | | |
| 2. Inability to maneuver well destruction vehicles and equipment in a constrained work area (equipment blocking access to well, consumables in immediate area) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | | 6 | 4 | 9 | 1. The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect | |

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| | | | | | | | | equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business interruption, particularly during Assemble String, Load Well and Detonate Charge phases. |
| | 2. Impact to Asset: Damage to equipment and consumables stored in well site location (e.g. vehicle wind screens at Southern Pacific Monitoring Well MW-16B) | A | Well containment used (mats, sacks of cement) | 6 | 6 | 10 | 1. | The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business interruption, particularly during Assemble String, Load Well and Detonate Charge phases. |
| | 3. Impact to Safety: potential for personnel and public vehicle/pedestrian interaction | S | Placement of "hard" barricades (visual screening to prevent sight-seers)<br>Traffic control setup<br>Implementing Motor Vehicle Safety "spotter" requirements | 3 | 5 | 7 | 2. | The concern is possible vehicle/pedestrian interaction whilst maneuvering well destruction vehicles and equipment in a constrained work area. The team noted sites may have multiple buildings, equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment. Recommend to consider performing field walk through of designated route particularly when backing |

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| | | | | | | | vehicles. | |
| 3. General equipment failure (truck breakdown, equipment inoperable, traffic accident, equipment left behind) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Pre-shift inspection checklists and inspections (DOT ready, review materials,equipment, toolbox review)<br>Project Data Sheet for inventory checks (supplies)<br>Distributor delivers explosives to site according to bill of lading | 6 | 4 | 9 | | |
| 4. Uncooperative site personnel or customers /visitors (conflicting operations);Third party personnel entering worksite during setup (e.g. wind screen company personnel at Southern Pacific Monitoring Well MW-16B) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Pre-shift inspection checklists and inspections (DOT ready, review materials,equipment, toolbox review)<br>Project Data Sheet for inventory checks (supplies)<br>Distributor delivers explosives to site according to bill of lading | 6 | 4 | 9 | 1. The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business interruption, particularly during Assemble String, Load Well and Detonate Charge phases. | |
| | 2. Impact to Safety: potential for personnel and public contact with explosives or projectiles | S | Setup barrier tape (50' blast exclusion zone and 25' work zone for explosive transfer )<br>Signage (explosives)<br>Posted sentry<br>Blaster continually monitors exclusion zone | 4 | 5 | 6 | 1. The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well | |

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| | | | | | | | | destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business interruption, particularly during Assemble String, Load Well and Detonate Charge phases. | |
| 5. Extreme weather events (e.g. lightning, flooding etc.) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Lightning Procedure (30/30) stop work<br>Weather forecasting<br>Materials are covered (weather proofed) and secured | 6 | 5 | 10 | | | |
| | 2. Impact to Safety: potential for personnel and public contact with explosives or projectiles | S | Exclusion zone while transferring explosives from delivery van to day box<br>OSHA standard for controlling transfers of explosives during extreme weather events (reference required)<br>Weather forecasting | 3 | 5 | 7 | | | |
| 6. Core personnel unavailable (sick) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Stop Work<br>Reschedule project activities<br>Second Blaster on-call within 24 hr | 6 | 6 | 10 | 3. | Concern is delay to project schedule with associated "standby" costs and remobilization and loss to materials should core personnel be unavailable (e.g. sickness). The team discussed the criticality of each skill set that are essential to completing the well abandonment operation in particular the need for a competent Blaster. Recommend to consider implementing a requirement for personnel to provide a 24-hr notification of not being fit for duty. | |
| 7. Mechanical / manual handling incident e.g. | 1. Impact to Asset: Dropped object damaged leading | A | Pre-start warm ups<br>Buddy lifting system( ≥50 lbs or awkward) | 6 | 4 | 9 | | | |

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| dropped object | to delay to project schedule with associated "standby" costs and remobilization and loss to materials | | Materials labeled with weight | | | | | | |
| | | | Stop work authority | | | | | | |
| | 2. Impact to Safety: potential for personnel contact with pinch points or struck by moving equipment | S | Stop work authority | 4 | 4 | 7 | | | |
| | | | Materials labeled with weight | | | | | | |
| | | | Buddy lifting system( ≥50 lbs or awkward) | | | | | | |
| | | | Pre-start warm ups | | | | | | |
| | | | Pre-employment screening | | | | | | |
| | | | Return to work policies (doctor clearance) | | | | | | |
| | | | Proper lifting techniques (training) | | | | | | |
| 8. Electrical utilities are disturbed | 1. Impact to Safety: potential for personnel and public contact with electrical utilities | S | Utility surveys and existing infrastructure | 3 | 5 | 7 | | | |
| | | | Pre-shift inspection checklists and inspections (DOT ready, review materials,equipment, toolbox review) | | | | | | |
| | | | Stop work authority | | | | | | |
| 9. Personnel contact with hot surfaces (e.g. trash pump muffler) | 1. Impact to Safety: Potential for heat burns to skin | S | | | | | 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard Analysis technique onsite with the whole work force to identify hazards, implement risk reduction safeguards and rehearse mitigation procedures prior to each step of the job. | Not ranked in workshop |
| 10. Personnel contact with cement grout (corrosive) | 1. Impact to Safety: Potential for chemical burns to skin | S | | | | | 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard | | Not ranked in workshop |

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| | | | | | | | Analysis technique onsite with the whole work force to identify hazards, implement risk reduction safeguards and rehearse mitigation procedures prior to each step of the job. | |
| 11. Personnel contact with well vapors (hydrocarbons) | 1. Impact to Safety: Potential for chemical inhalation | H | | | | | 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard Analysis technique onsite with the whole work force to identify hazards, implement risk reduction safeguards and rehearse mitigation procedures prior to each step of the job. | Not ranked in workshop |
| 12. Personnel contact with venomous creatures (snakes, spiders, bees, mosquitoes) | 1. Impact to Safety: Potential for adverse reaction to pathogens and allergens | S | | | | | 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard Analysis technique onsite with the whole work force to identify hazards, implement risk reduction safeguards and rehearse mitigation procedures prior to each step of the job. | Not ranked in workshop |
| 13. Personnel exposure to heat from sunlight | 1. Impact to Safety: Potential for heat stress | S | | | | | 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard Analysis technique onsite with the whole work force to identify hazards, implement risk reduction | Not ranked in workshop |

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| | | | | | | | safeguards and rehearse mitigation procedures prior to each step of the job. | |
| 14. Personnel exposure to noise from trash pump and vacuum truck | 1. Impact to Safety: Potential for noise induced hearing loss | H | | | | | 4. Concern is potential for onsite hazards to lead to health and safety consequences. The team discussed multiple causes of hazards to come into contact with personnel during the well abandonment activities. Recommend to consider utilising the Job Safety Analysis technique prior to mobilisation with work force representatives and Job Hazard Analysis technique onsite with the whole work force to identify hazards, implement risk reduction safeguards and rehearse mitigation procedures prior to each step of the job. | Not ranked in workshop |

**Node Title:** 2. Assemble String

**Drawing:** Blasting Work Plan Chevron MW-4

**Design Intent:** Only detonation string being utilized (no boosters)

Tremie pipe threaded (not coupled)

| What If? | Consequences | CC | Safeguards | Risk Priority | | | Recommendations | Comment 1 |
|---|---|---|---|---|---|---|---|---|
| | | | | C | L | Risk | | |
| 1. Personnel entering exclusion zone while assembling string | 1. Impact to Safety: personnel and public (ranked on public) contact with explosives or projectiles | S | Signage (exclusion zone) | 2 | 5 | 6 | 5. The concern is members of public entering the blast exclusion zone which is marked by caution tape. The team discussed the potential for members of the public, particularly children, to by-pass caution tape which marks the exclusion zone. Recommend to consider alternative methods to reduce potential for personnel and public entry into the exclusion zone (e.g. hard barricades). | |
| | | | Posted sentry | | | | 1. The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business | |
| | | | Caution tape | | | | | |

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| | | | | | | | interruption, particularly during Assemble String, Load Well and Detonate Charge phases. | |
| 2. Equipment damage to detonation string / trunk line due to third party activities | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Signage (exclusion zone)<br>Posted sentry<br>Caution tape | 6 | 6 | 12 | 6. The concern is possibility of blast string or trunkline damage leading to misfire and requirement to run another string or displace the grout from the wellbore and start again. The team discussed the damage could occur due to persons inadvertently pulling the blast string or trunkline against snag hazards and casing sharp edges. Recommend to consider minimizing sharp edges, adding protective tape to required sharp edges and enforcing good housekeeping activities where the string may come into contact with casing, well containment device and other touch points. | |
| 3. Proper connections are not made (water-tight) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Visual inspection of connections, taping, and weighting detonation string | 6 | 6 | 12 | | |
| 4. Not possible to get to well total depth (TD) (junk in hole, wellbore collapse etc.) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Measure well total depth (TD) and communicate with all involved in tasks.<br>Based on driller's log, tagged depth, regulator approval and string length | 6 | 6 | 12 | 7. The concern is delay of project schedule if the total depth of the well cannot be achieved. The team discussed potential for root growth into wellbore or hole collapse to prevent the installation of the blast string to total depth. Recommend to consider pre-mobilization survey (schedule with USA marking surveys) and remediation to achieve actual measured well total depth (TD) prior to mobilization of the well destruction team. | |
| 5. Snap flash detonation (vehicle third party contact) | 1. Impact to Safety: personnel contact with unintended detonation of explosive charges | S | Trunkline spool is rolled up and blaster is guarding spool<br>All moving vehicles parked outside of exclusion zone<br>Non-electrical trunkline | 2 | 5 | 6 | 8. The concern is possibility of blast string or trunkline damage leading to premature firing, misfire and requirement to run another string. The team discussed the string damage could occur due to accidental contact with the trunkline by equipment and vehicles. Recommend to setup routing operations prior to installing string to reduce potential for accidental contact with the trunkline. | |

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| 6. Damage to detonation string (contact with Tremie pipe) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | S | Visual inspection of connections, taping, and weighting detonation string<br>Tremie pipe is loaded into well first prior to string<br>Tremie pipe is flush joint | 6 | 6 | 10 | | |
| 7. Disconnection of blasting cap from detonation cord | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Visual inspection of connections, taping, and weighting detonation string<br>Standard operating procedure: cap is knotted with a half hitch and taped on | 6 | 6 | 10 | | |
| 8. Explosives used by un- authorized personnel or Blaster does not have competency (experience or training) | 1. Impact to Safety: personnel and public (ranked on public) contact with explosives or projectiles | S | 5 yr apprenticeship prior to OSHA blasting license<br>5 yr blasting license renewal<br>Ongoing training<br>ATF annual clearance<br>Sheriff Dept county explosive permits required for work (purchase & use of products)<br>Licensed company delivers explosive product | 1 | 6 | 6 | 9. The concern is explosives may be delivered to non-authorized personnel at the well abandonment work site. The team discussed the potential for illegal or terrorist use of the explosives if the delivery company does not check the qualifications of the person taking receipt of the explosives onsite. Recommend to consider making a request to the licensed explosives delivery company to review how their procedures ensure explosives are only provided to authorized personnel. | |

**Node Title:** 3. Load Well

**Drawing:** State of CA Division of Occupational Safety And Health, Blaster Certification/License ; Classification (E) Limited: Well Service Blasting (Limitation) Nonelectric initiation only

**Design Intent:** Weight and drop method of lowering string into well
Composition of sealant material to meet requirements of CWC 74.90
Placement of sealant material to meet requirements of CWC 74.90

| What If? | Consequences | CC | Safeguards | Risk Priority | | | Recommendations | Comment 1 |
|---|---|---|---|---|---|---|---|---|
| | | | | C | L | Risk | | |
| 1. Foreign objects in grout leading to clogging of hoses and tremie pump | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Mix cement grout in barrel/drum agitated by mechanical means<br>Visual viscosity check<br>Pump inlet screen<br>Quality control of material used (protected from moisture in transport and storage) | 6 | 5 | 10 | 10. The concern is on-site quality control of cement grout slurry mix may not meet regulatory requirements for cement grout composition. The team discussed the variability of quality achieved if visual or volumetric measures were used. Recommend to utilize mud scales to measure cement grout composition to meet regulatory requirements for cement grout composition. | |
| 2. Viscosity too thick resulting non-pumping | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Visual viscosity check | 6 | 5 | 10 | 11. The concern is the potential for cement grout viscosity to exceed the pumping ability through tremie pipe. The team discussed this may prevent the cement trash pump from keeping prime. Recommend to consider adding viscosity and flow improvers to cement grout to improve pumping characteristics. | |

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| | | | Regulatory standard for cement grout composition | | | | 12. Concern is the requirement for regulatory approval of cement grout additives to achieve desired properties for operational and contingency measures. The team discussed the need to add viscosity and flow improvers to cement grout to improve pumping characteristics, retarder to allow placement of a propagation charge should the initial charge misfire or hangfire. Recommend to enter into early negotiation with the Regulator to gain approval for cement grout additives. | |
| 3. Hose blows due to overpressure | 1. Impact to Safety: Personnel contact with high pressure grout and hose whip | S | Pre-use equipment visual inspections<br>Inlet screen (to prevent discharge blockage)<br>PPE (includes eye protection)<br>Trained and competent personnel (grout training) | 4 | 4 | 7 | 13. The concern is potential for personnel to be injured by cement pump discharge hose whip due to overpressure failure. Recommend to consider the use of whip checks on cement pump discharge hoses. | |
| 4. Displaced water is not contained | 1. Impact to environment: High pH content waste water (approx. 20 gallons) | E | Water tee routed to drum for capturing returns to surface<br>Downhole monitoring of the free water level<br>Third party waste service for disposal of displaced water | 6 | 6 | 10 | 14. Concern is regulatory standards may require displaced water from the well to be treated as waste requiring offsite disposal. The team discussed the potential for displaced water from the well to be reused to create cement grout for the next well to be abandoned. Recommend to negotiate with Regulator to gain approval for reuse of displaced water to make cement grout. | |
| | 2. Impact to Safety: Potential impact (skin and eye irritation due to contact with high pH water). (Also ranked a consequence of 5 for health) | S | PPE includes nitrile gloves and safety glasses with a face-shield while pumping cement grout<br>On-site first aid including eye wash | 5 | 6 | 10 | | |
| 5. Uncooperative site personnel or customers /visitors (conflicting operations); inability to set up | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Pre-shift inspection checklists and inspections (DOT ready, review materials,equipment, toolbox review)<br>Project Data Sheet for inventory checks (supplies)<br>Distributor delivers explosives to site according to bill of lading | 6 | 4 | 9 | | |

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| 50' blast exclusion zone | 2. Impact to Safety: personnel and public (ranked on public) contact with explosives or projectiles | S | Setup barrier tape (50' blast exclusion zone and 25' work zone for explosive transfer ) | 2 | 5 | 6 | 1. The concern is potential impacts to current business operations on the site during well abandonment. The team discussed the possibility of adjacent neighbors to be affected due to the location of the well on the site being within 50 ft of the boundary which may require them to cease operations to maintain the exclusion zone and the possibility of equipment and consumables stored onsite to prevent access for well destruction vehicles and equipment and within the exclusion zone which may need to be temporarily relocated to reduce possible damage. Recommend to consider early onsite meeting with Property Owner, Welenco and Project Manager to identify access requirement and exclusion zone areas and determine the need to temporarily relocate from the exclusion zone or protect equipment (e.g. blast shields or tarps) which cannot be relocated and make agreement to suspend business operations during well abandonment activities and choose timing to minimize their business interruption, particularly during Assemble String, Load Well and Detonate Charge phases. | |
| | | | Signage (explosives) | | | | 5. The concern is members of public entering the blast exclusion zone which is marked by caution tape. The team discussed the potential for members of the public, particularly children, to by-pass caution tape which marks the exclusion zone. Recommend to consider alternative methods to reduce potential for personnel and public entry into the exclusion zone (e.g. hard barricades). | |
| | | | Blasting warnings (area clear check, air horn blast prior to detonation, bull horn call-out, then air horn blast all clear) | | | | | |
| 6. Detonation cord or charge moves from planned placement in wellbore | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Detonation cord weighted to bottom of hole using a 1.5 lb steel weight | 6 | 6 | 10 | 15. Concern is reentry to the well to allow contingency measures should the detonation cord/charge move from planned placement in wellbore or a misfire or hangfire of the charge. The team discussed the potential for the cement to set during the time required to circulate out cement grout to | |
| | | | Visual inspection of connections, taping, and weighting detonation string | | | | | |
| | | | Tremie pipe in the hole prior to load of detonation cord | | | | | |
| | | | Tremie pipe raised during pumping | | | | | |
| | | | Visual monitoring of detonation cord (tension and position of top casing mark) to ensure weight is still connected to string | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | | | Circulate out cement grout to recover well total depth (TD) to reset detonation cord at well total depth. | | | | recover well total depth or to rig up and deploy a propagation charge to well total depth. Recommend to consider a retardant additive to cement grout to allow contingency measures (e.g. circulate out cement grout to recover well total depth, deploy charge downhole). | |
| 7. Tremie pipe is too large | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Project datasheet informs crew of correct size of tremie pipe for well abandonment | 6 | 6 | 36 | | |
| 8. Personnel exposed to detonation fumes (dynamite headache) | 1. N/A (no nitrates and heavy metals in detonation cord) | | | | | | | |
| 9. Detonation cord splices come undone | 1. N/A no splice since detonation cord length exceeds total depth | | | | | | | |

**Node Title:** 4. Detonate Charge

**Drawing:**

**Design Intent:** Remain below peak velocity of 3"/sec and charge of size no greater than 50 grains/ft for PVC wells

Seismograph sample rate from 1,024 to 16,384 S/s per channel up to 65,536 S/s available on a single channel

| What If? | Consequences | CC | Safeguards | Risk Priority | | | Recommendations | Comment 1 |
|---|---|---|---|---|---|---|---|---|
| | | | | C | L | Risk | | |
| 1. Poor connection at shooter | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Physical inspection of detonation cord connection to shooter per SOP<br>Spare shooter<br>Spare 209 primers | 6 | 6 | 18 | | |
| 2. Damaged trunkline by placing containment device over well | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Use water tee as conduit for trunkline | 6 | 6 | 18 | | |
| 3. Misfire (includes hangfire) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Misfire procedures<br>Redundancy in string (two caps, two separate lines)<br>Propagation charge (secondary backup charge) is used as "last resort" contingency | 6 | 6 | 18 | 15. Concern is reentry to the well to allow contingency measures should the detonation cord/charge move from planned placement in wellbore or a misfire or hangfire of the charge. The team discussed the potential for the cement to set during the time required to circulate out cement grout to recover well total depth or to rig up and deploy a propagation charge to well total depth. Recommend to consider a retardant additive to cement grout to allow contingency measures (e.g. circulate out cement grout to recover well total depth, deploy charge downhole).<br>12. Concern is the requirement for regulatory approval of cement grout additives to achieve desired properties for operational and contingency measures. The team discussed the need to add | |

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| | | | | | | | viscosity and flow improvers to cement grout to improve pumping characteristics, retarder to allow placement of a propagation charge should the initial charge misfire or hangfire. Recommend to enter into early negotiation with the Regulator to gain approval for cement grout additives. | |
| | 2. Impact to Safety: Personnel in exclusion zone contact with explosives or projectiles | S | Blaster in charge monitoring for unauthorized personnel<br>Barricades and signage<br>Misfire procedures | 3 | 6 | 18 | | |
| 4. Failure of containment device | 1. Impact to Safety: Personnel contacted by cement grout | S | Containment device (55 gallon drum) with 94 lb of cement sack on top<br>Exclusion zone of 50 feet<br>PPE includes safety glasses<br>Protective plastic sheeting | 5 | 5 | 25 | | |
| 5. Vibration (air or ground) in excess of design | 1. Impact to Asset (utilities e.g. telecommunication fiber optics and existing infrastructure e.g. fuel tanks and adjacent pipeline) | A | Blast design takes into consideration of existing assets and utilities to keep peak particle velocity below 3 inches per second to minimize shock waves<br>Seismic graph (monitoring and recording of the particle velocity) | 5 | 5 | 25 | 16. Concern is future wells to be abandoned may be adjacent to existing assets and utilities which may be damaged due to excess vibration from the explosive shock wave. The team discussed the need to estimate damage to assets and utilities by conducting detailed blast modeling to determine safe distances and charge density however, there is currently insufficient propagation velocity data for typical soil types. Recommend to conduct multiple seismic monitoring at test well sites in typical soil types to gather velocity data to support future detailed blast modeling of future wells which are adjacent to existing assets and utilities. | |
| 6. Seismic detector damaged by blast (fly rock) | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization and loss to materials | A | Spare seismic detector on call<br>Placement of seismic detector approximately 10 ft from well hole<br>Design of seismic detector to withstand blast | 6 | 6 | 36 | | |
| 7. Seismic detector | 1. Impact to Asset: | A | Bi-annual certification and calibration of seismic detector by manufacturer | 4 | 6 | 24 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| not calibrated | peak particle velocity measures inaccurate | | Blast design takes into consideration of existing assets and utilities to keep peak particle velocity below 3 inches per second to minimize shock waves | | | | |
| | | | Liability insurance of contractor | | | | |

**Node Title:** 5. Backfill and Restore

**Drawing:**

**Design Intent:** Well destruction to meet requirements of CWC 74.90

| What If? | Consequences | CC | Safeguards | Risk Priority | | | Recommendations | Comment 1 |
|---|---|---|---|---|---|---|---|---|
| | | | | C | L | Risk | | |
| 1. Top 5' of casing cannot removed | 1. Impact to Asset: Delay to project schedule with associated "standby" costs and remobilization | A | Regulator allows variation with each application<br>Utility surveys and existing infrastructure | 6 | 6 | 10 | | |
| 2. Difficulty manual handling removal of top 5' casing | 1. Impact to Safety: Potential for sprains and strains | S | Pre-employment screening<br>Warm ups<br>Proper lifting techniques (training)<br>Buddy lifting system( ≥50 lbs or awkward)<br>Stop work authority<br>Return to work policies (doctor clearance) | 4 | 4 | 7 | | |
| 3. Displaced well fluids (water) from well at surface | 1. Impact to environment: Discharge of high pH content waste water (approx. 20 gallons) | E | Waste water at surface collected (water tee into drum)<br>Containment of displaced water to surface with holding tank<br>Prior testing of well (well total depth (TD)) depth prior to mobilization | 5 | 5 | 9 | 17. Concern is the potential for excessive displacement of displaced water from the well at the surface due to the regulatory requirement to place cement grout from well total depth to the surface. The team discussed the potential for displaced water from the well to be reduced by placing the cement grout from above the water level to displace water back to the formation rather than displacement to surface. Recommend to consider negotiation with the Regulator to allow placement of cement grout without tremie pipe or tremie pipe placement above well total depth to place the cement grout above the water level and displace water back to the formation. | |
| 4. Downward migration of surface water | 1. Impact to Asset: Regulatory request for data to support | A | Visual inspection during mixing and placing<br>Excavation is bigger than borehole | 6 | 6 | 10 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (rain) resulting from poor mushroom cap | proper well abandonment has been achieved | | Regulator signs off in field | | | | | |
| 5. Seal is not achieved to prevent vertical migration inside borehole / well casing | 1. Impact to Asset: Regulatory request for data to support proper well abandonment has been achieved | A | Visual inspection during mixing and placing | 6 | 6 | 10 | | |
| | | | Regulator signs off in field | | | | | |
| | | | cement grout placement procedure | | | | | |
| | | | Detonating well blocks potential flow path from surface to water bearing zone | | | | | |